TECHNICAL NOTES.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

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THE DETERMINATION OF THE EFFECTIVE RESISTANCE OF A SPINDLE SUPPORTING A MODEL AEROFOIL.

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The technical staff of the National Advisory Committee for Aeronautics, in testing aerofoils at the Langley Memorial Aeronautical Laboratory, has made the following determination of effective resistance of a spindle support of a model aerofoil.

The largest correction to be applied to the values of the forces observed during model aerofoil tests is usually that necessitated by the presence of some mechanical device used to support the model in the airstream. A customary form of support consists of a round tapered spindle screwed into the end of the wing, which is usually partially shielded from the airflow by some type of streamline housing.

The effect of this holding spindle may be considered in two parts, viz.: the actual resistance of the spindle, due to the air pressure upon it, and the disturbance of the natural aerodynamic characteristics of the model due to the proximity of the spindle and its housing. It is obvious that a housing extending nearly to the wing decreases the direct spindle drag but increases the interference. The most desirable length of housing is one which reduces the total correction to a minimum. The housing used in this series of tests was constructed to fit as closely as possible about the supporting spindle and it was found by experiment that it could be brought within one inch of the wing without causing excessive interference.

In order to determine what correction to apply for spindle drag and interference it is customary to support the wing as shown in Figure 3, holding it at the center of the span rather than at the tip as is the usual practice. A dummy housing and spindle are then prepared which may be mounted in the same position relative to the wing which they ordinarily occupy during routine testing, the dummy spindle being fastened to the wing tip and projecting into the hollow opening of the housing, but not touching it at any point. Runs are then made over a series of speeds and angles of incidence both with and without the dummy spindle and housing in place. The difference in drag readings between a pair of such runs is an actual measure of the combined effect of spindle drag and interference on the wing drag.

As the N.P.L. type of balance, such as was used for these tests, measures moments rather than forces, it is also necessary to determine at what point this correction must be applied. To arrive at this value a record is made of moments about the vertical spindle corresponding to the various readings. If the moment correction be divided by the force correction the quotient is a measure of the distance C from the axis of rotation to the center of pressure or the point of application of the force.

In applying these corrections to measurements obtained from an N.P.L. balance using the usual type of mounting (Fig. 1), their magnitude must be reduced in the proportion of $\frac{L-C}{L}$, where L is the distance from the balance pivot to the center of the wing, because of the changed position of their point of application (see Fig. 3).

An attempt was made to determine the effect of spindle interference on the lift of the aerofoil by measuring moments about the axis parallel to the direction of airflow. The values obtained are of the same degree as the experimental error and for the present this effect will be neglected.

The results obtained using a U.S.A.15 wing, plotted in Figure 4, show that the correction is nearly constant from 0° to 10° incidence and that at greater angles its value becomes erratic. At such angles however the wing drag is so high that the spindle correction and its attendant errors become relatively small and unimportant.

Figure 5 shows the variation of the ratio

$$\frac{\text{Drag correction}}{(\text{Velocity})^2}$$

when plotted against velocity for an incidence of 0°, showing that the proportional correction decreases appreciably with increased velocity.

The accurate determination of the location of the center of pressure is below the range of sensitivity of the balance but calculations show that this may safely be assumed at the center of the spindle.

Although the accuracy of the determination of the drag corrections is not great it will be seen from the following example that the percentage error when applied to the total wing drag is not appreciable.

Measured spindle correction at 4° incidence at 21 m/sec = 6.2 gm. ± probable error of .5 gm.

Distance of point of application from center of wing span, 24.2 cm.

Distance from center of wing span to balance pivot 137.2 cm.

Drag of wing + spindle at 4° incidence at 21 m/sec. = 31.7 gm.

Probable error in applied correction =

$$\frac{.5 \times (137.2 - 24.2)}{137.2} = .41$$

Percent of probable error in drag due to spindle correction =

$$\frac{.41}{31.7 - \frac{6.2(137.2 - 24.2)}{137.2}} = 1.5\%$$

(NOTE: See also Advisory Committee for Aeronautics (British) reports Nos. 148, 198, and 244).

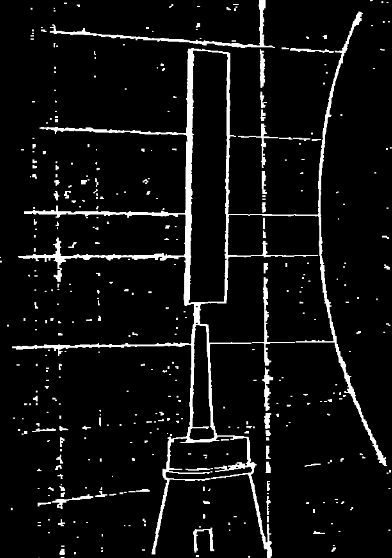


Fig. 1.

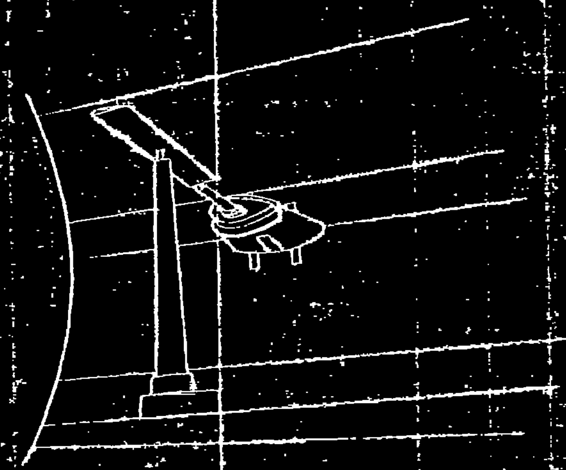
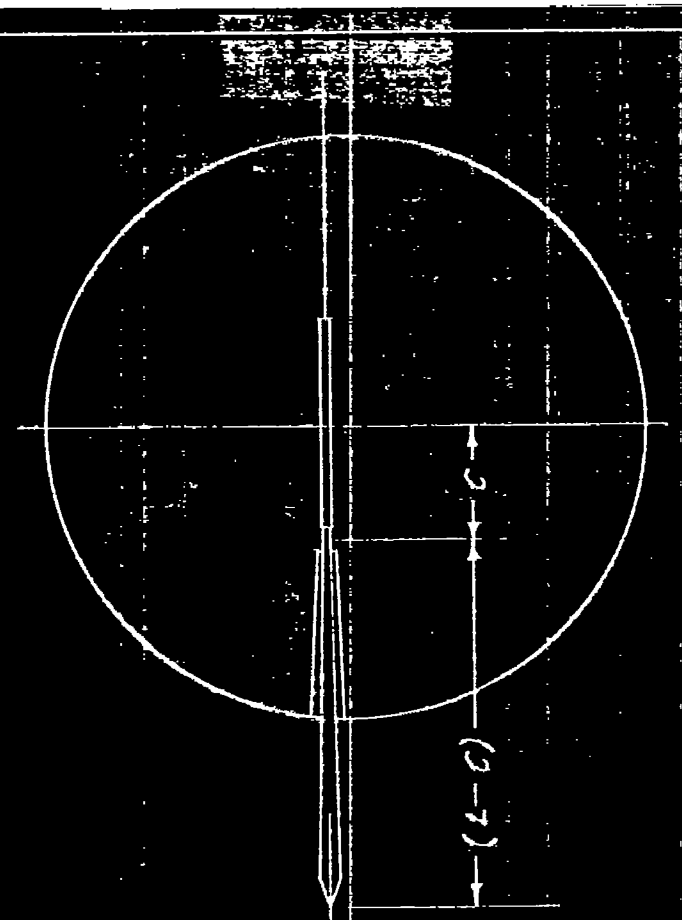
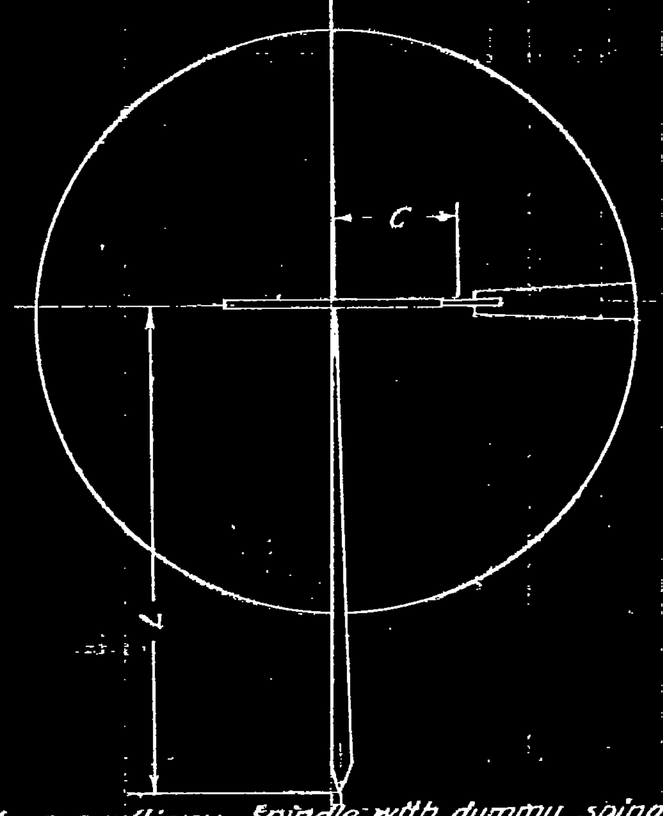


Fig. 2.

Fig. 1 & 2.

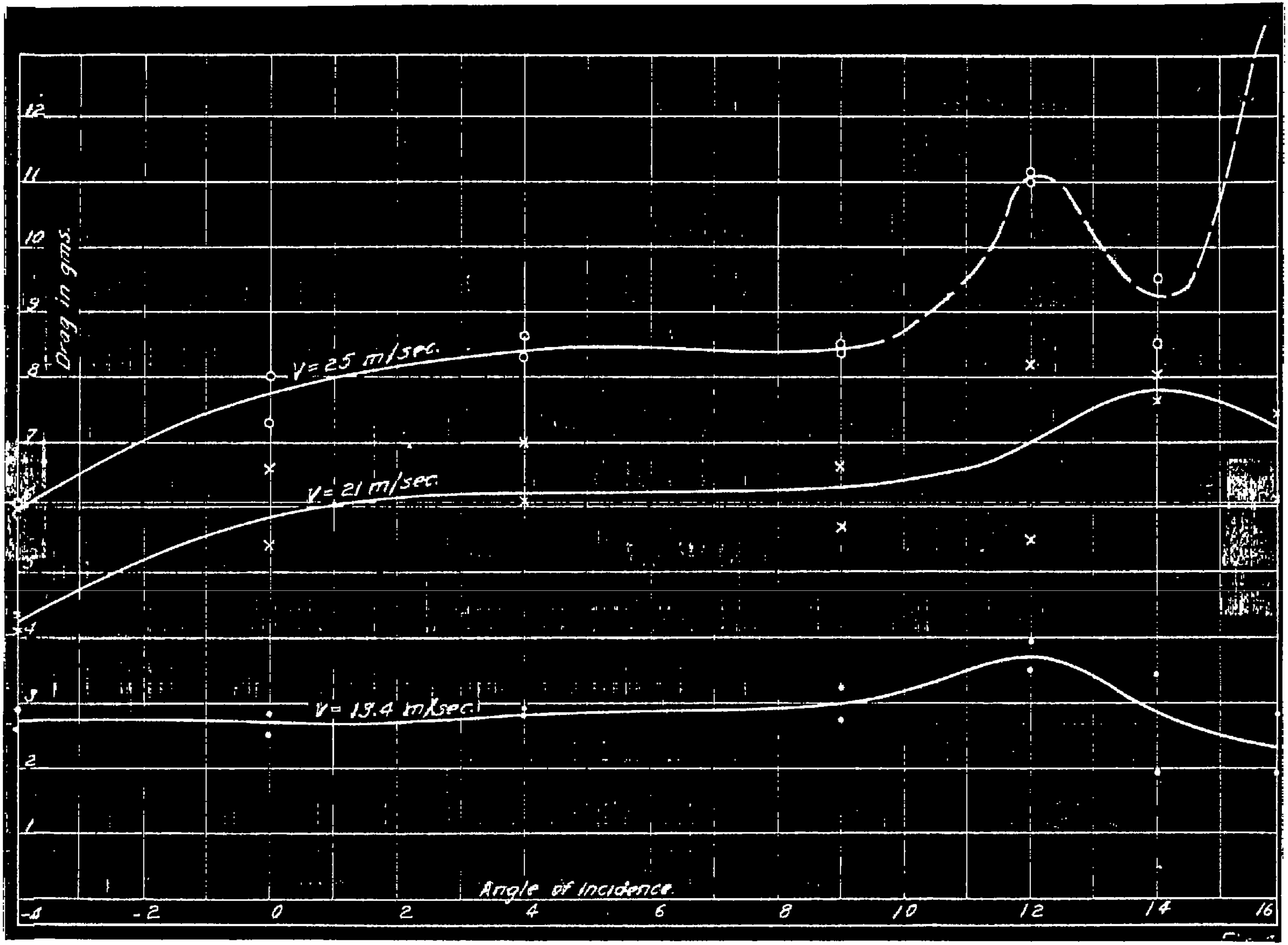


Wing mounted on Standard Spindle.

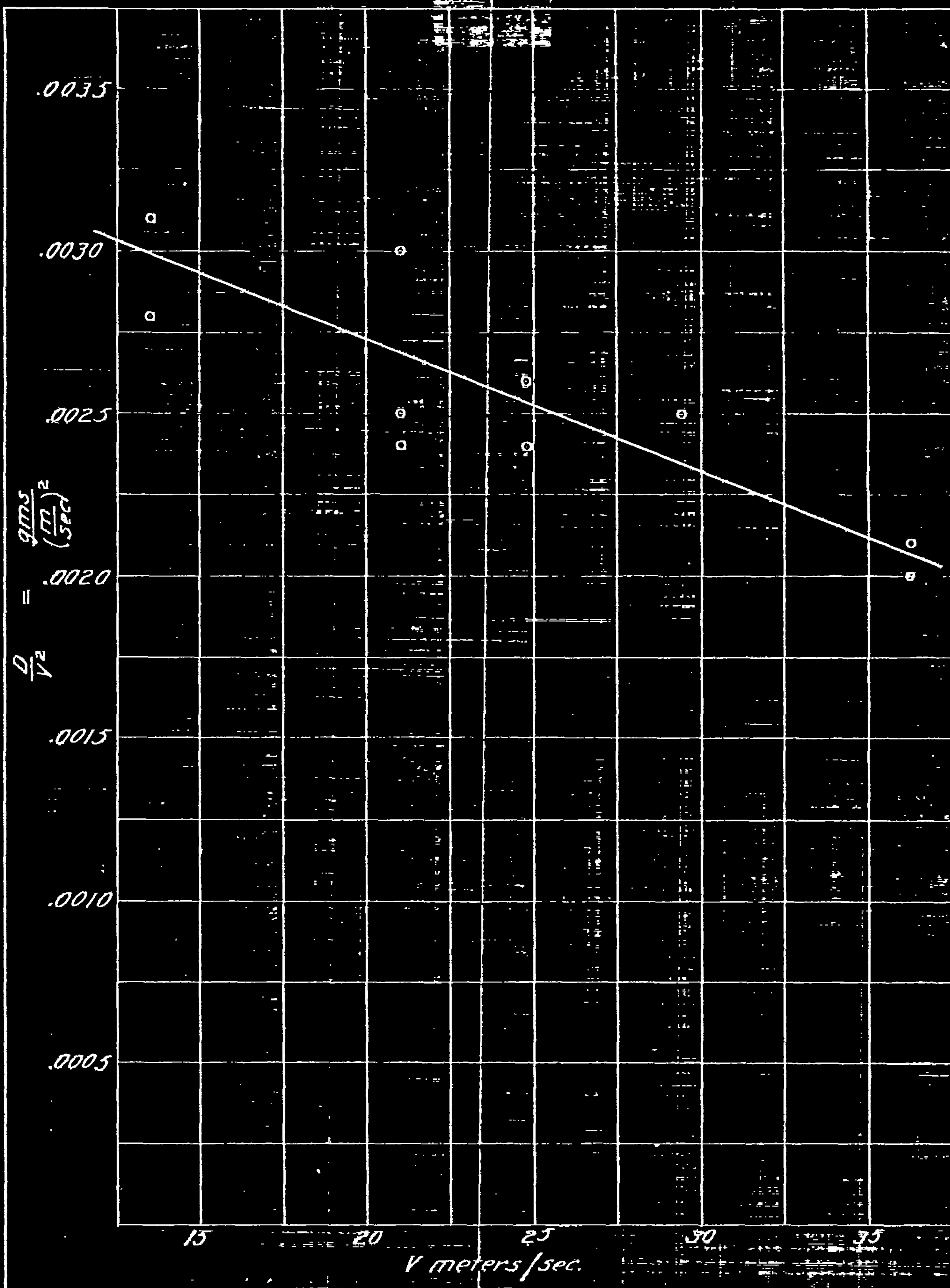


Wing mounted on auxiliary Spindle with dummy spindle and housing mounted on wall.

Fig. 3.



Drag in gms.
Angle of Incidence.
V = 25 m/sec.
V = 21 m/sec.
V = 13.4 m/sec.
12
11
10
9
8
7
2
1
-2
0
2
4
6
8
10
12
14
16



SPINDLE CORRECTION COEFFICIENT.
U.S.A. 15 at 0° Incidence.

Fig. 5.